Effect of Integrating Animation Videos into Science Instruction in Under-Resourced Rural Nigerian Schools

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Abstract

This study investigates the effect of integrating animation videos into science instruction on students' academic achievement in rural Nigerian secondary schools, where access to educational technology such as electricity supplies is limited. While global interest in video-based pedagogy is increasing, empirical research on its use in under-resourced African classrooms remains limited. This quasi-experimental study involved 83 Junior Secondary Two students from two intact classes. The experimental group received traditional science instruction supported by animation videos preloaded on the teacher's smartphone, while the control group received lecture-only instruction. Guided by three hypotheses, achievement was measured using two validated research instruments: a researcher-adapted Science Aptitude Test (SAT) and the Basic Science Achievement Test (BSAT), with reliability coefficients of 0.711 and 0.68, respectively. Independent samples t-tests revealed statistically significant differences in achievement favoring the animation-supported instruction. Further analysis showed a significant interaction between instructional method and student ability level, with higher gains among both high- and low-ability students in the experimental group. The findings underscore the value of integrating context-appropriate video resources into classroom teaching to support differentiated learning, even in infrastructure-limited settings. This study has implications for teacher training, curriculum development and low-cost technology integration and it contributes to a nuanced understanding of learning processes in marginalized educational contexts such as rural communities in developing countries like Nigeria.

Keywords: animation videos, smartphones technology, ability levels, science achievement, rural communities

1. Introduction

Persistent underachievement in science subjects among secondary school students remains a pressing concern in many educational systems, particularly in rural communities which are low-resource contexts. In Nigeria, reports from examination bodies (WAEC, 2020; NECO, 2019) and academic researchers (Alsadoon, Alkhawajah, & Suhaim, 2022) highlight the limitations of conventional instructional methods as a significant factor in this trend. These traditional approaches often fail to align with students' learning preferences and cognitive needs, especially in environments where engagement and interaction are crucial for conceptual understanding (Atomatofa, Okoye & Igwebuike 2016).

Contemporary research underscores the pedagogical value of animation videos in enhancing student engagement, motivation, and academic performance (Noetel et al., 2021; Anthony et al., 2019). Digital videos, when effectively integrated into instruction, have been shown to foster deeper learning by presenting concepts through both visual and auditory modalities (Blasco et al., 2016; Tang & Austin, 2019). This dual coding of information can enhance retention, stimulate interest, and support differentiated learning across varied ability levels (Tani, Manuguerra, & Khan, 2022). However, most of these findings derive from studies conducted in well-resourced settings or through online platforms, leaving a critical gap in understanding the effectiveness of animation video-instruction in face-to-face, rural educational contexts with limited technological infrastructure.

In Nigeria rural schools frequently lack access to digital tools, experience epileptic electricity supply, and poor internet connectivity which hinders the implementation of technology-enhanced teaching methods (Omini & Ofre, 2021). Despite this, recent innovations have demonstrated that instruction along with animated educational videos preloaded on mobile devices can offer a pragmatic alternative for resource-constrained settings. animated video instruction, using smartphones equipped with pre-installed science lessons, represents a potentially transformative approach, particularly when tailored to the specific needs of learners with diverse ability levels.

This study compares the effect of using two instructional strategies (integrating animation videos into science instruction and traditional lecture methods) on students' achievement in Basic Science. It also examines whether students with varying ability levels benefit from such blended instructional strategies in rural educational settings. By situating this work within the broader discourse on multimodal learning and educational equity, the study aims to contribute to the growing body of research on how innovative, low-cost instructional technologies can support deeper learning in under resourced contexts.

1.1 Theoretical Framework

This study is underpinned by the Dual Coding Theory of Memory (Paivio, 1991; Clark & Paivio, 1991), which offers a robust cognitive explanation for how individuals process and retain information. Dual Coding Theory posits that learning is most effective when instructional content activates both verbal and non-verbal cognitive systems. The verbal system is responsible for processing linguistic information, while the non-verbal system manages imagery and other visual-spatial representations. These systems operate independently but can interact to reinforce memory and comprehension.

According to Paivio, information encoded through both systems—such as spoken language paired with visual imagery—is more likely to be retained than information encoded through a single modality. This theory introduces two distinct categories of representational units: logogens, which facilitate the processing of verbal information, and imagens, which cater to the assimilation of visual stimuli (Sadoski & Paivio, 2001). The integration of these codes strengthens cognitive connections and enhances the learner's ability to recall and apply knowledge.

In educational contexts, particularly in science education where abstract and complex concepts are common, the implications of Dual Coding Theory are significant. Instructional animated videos, which combine spoken explanations with dynamic visual representations, exemplify a dual-coded approach. Marzano, Pickering, and Pollock (2001) highlight that such multimedia tools not only support the development of non-linguistic representations but also facilitate deeper cognitive engagement and improved learning outcomes.

This theoretical lens is particularly relevant in the context of rural education in Nigeria, where traditional lecture-based instruction may inadequately support students' cognitive needs. The use of pre-installed instructional videos on smartphones, as implemented in this study, is grounded in the principle that presenting information through both verbal and visual channels can foster more meaningful learning, especially for students with diverse cognitive abilities. By aligning pedagogy with the cognitive architecture proposed by Dual Coding Theory, this study demonstrates the value of multimodal animation video-instruction in enhancing science achievement in low-resource settings.

1.2 Literature Review

Scientific concepts are most effectively grasped when imparted through methodologies that captivate students' attention, rather than relying exclusively on rote memorization. Kalas and Redfield (2022) found that well-crafted videos significantly enhance students' comprehension of scientific principles, surpassing the efficacy of rote learning, traditional lectures, and conventional textbooks. Videos animate lessons and dynamic processes, transforming abstract concepts into concrete realities and stimulating curiosity among learners. Educators are therefore encouraged to design or adopt video content that vividly illustrates scientific concepts.

Animated videos also cultivate psychosocial classroom environments that foster inquiry, discussion, and collaborative learning. Students taught with video-based resources often exhibit heightened motivation, increased engagement, and stronger teacher–student interactions compared to traditional classrooms (Blasco et al., 2016; Moos & Bonde, 2016). Prior studies show that videos contribute to learning atmospheres conducive to retention of critical concepts and the development of logical reasoning (Mora, 2016). Similarly, Tani, Manuguerra, and Khan (2022) stress that dual presentation through verbal and visual cues bolsters recall and supports learners with diverse abilities. Empirical studies in Nigeria also highlight that video-enhanced lessons outperform traditional methods in science and mathematics (Ekwueme et al., 2016; Ekon & Edem, 2015).

Despite these advantages, challenges persist. Integrating technology in rural schools is often undermined by systemic barriers such as irregular electricity supply, limited teacher ICT literacy, inadequate maintenance capacity, and poor infrastructure (Ekwueme et al., 2016; Ekon & Edem, 2015; Omini & Ofre, 2021). Research from similar contexts indicates that technology adoption sometimes fails due to poor sustainability planning, over-reliance on donor-funded devices, and limited teacher training (Wang & Hanna, 2018; Sung, Choi, & Lee, 2018). These cases underscore the importance of designing video-based interventions that are realistic, context-sensitive, and supported by local capacity building. Addressing these challenges not only strengthens the theoretical rationale for using animated videos but also makes the argument for technology integration more persuasive and grounded in reality. This study therefore seeks to extend existing scholarship by testing whether preloaded animated videos on smartphones, when used alongside teacher instruction, can overcome infrastructural barriers and enhance student learning outcomes in rural Nigeria.

1.3 Research Gap

Although numerous studies affirm the potential of video-based learning to improve science achievement, most have been conducted in technologically advanced contexts, leaving limited understanding of how such strategies perform in under-resourced rural environments. Moreover, few studies have examined whether learners of different ability levels benefit equally from animation video-instruction. By addressing these gaps, this study contributes evidence relevant for policymakers and practitioners seeking cost-effective, inclusive, and context-appropriate pedagogical innovations in Sub-Saharan Africa.

1.4 Aim of the Research

The main aim of this study was to determine whether the use of in-class animation videos preloaded on smartphones, when combined with teacher instruction, would improve students' knowledge of Basic Science concepts more effectively than lecture-only instruction. The study was guided by two research questions and three research hypotheses.

1.4.1 Research Questions:

i. Does integrating animation videos into science instruction improve students' achievement on the Basic Science Achievement Test (BSAT) compared to lecture-only instruction?

ii. How does the integration of animation videos into science instruction affect the science achievement of students with high and low ability levels in under-resourced rural schools?

1.4.2 Research Hypotheses

i. There is no significant difference in Basic Science Achievement Test (BSAT) scores between students taught using integrated animation video into instruction and those taught using lecture-only instruction.

ii. There is no significant difference in BSAT scores between high-ability and low-ability students taught using integrated animation video into instruction, compared to those taught using lecture-only instruction.

iii. There is no significant interaction effect between instructional method (animation video integration vs. lecture-only) and students' ability level (high vs. low) on their science achievement.

2. Method

2.1 Research Design

In this study, a non-equivalent pretest–post-test control group design was adopted. This design was chosen because random assignment of students to groups was not feasible; intact classes were maintained to reflect authentic classroom settings. Two groups were used: an experimental group that received animation-based instruction and a control group that received lecture-only instruction. Both groups were given a pretest to establish baseline equivalence, followed by a post-test after the instructional intervention.

This quasi-experimental design enabled both within-group and between-group comparisons, thereby assessing the effect of instructional methods on students' science achievement. The inclusion of a pretest helped to control for pre-existing differences between groups and enhanced the internal validity of the study. The design is particularly appropriate in school-based research, where randomization is constrained by logistical and ethical considerations.

2.2 Sampling and Sampling Procedure

The population consisted of 365 Junior Secondary Two (JSS2) students from public secondary schools in Mosogar town, a rural community in Delta State, Nigeria. A two-stage sampling method was employed.

First, purposive sampling was used to select two schools with comparable characteristics in infrastructure, teacher qualifications, and academic performance, to minimize school-level confounding variables. Second, intact class sampling was applied within each school: one JSS2 class in School 1 was assigned to the control group (lecture method), while one JSS2 class in School 2 was assigned to the experimental group (animation-based instruction).

All selected students completed a pre-intervention Science Achievement Test (SAT) to assess prior knowledge. Based on their scores, students were categorized into high-ability (≥ 70%) and low-ability (< 40%) groups. Students scoring between 40%–69% (middle ability), as well as those absent or failing to complete the SAT, were excluded to ensure distinct group comparisons.

After screening, the control group (School 1) comprised 19 high-ability and 21 low-ability students (n = 40), while the experimental group (School 2) had 23 high-ability and 20 low-ability students (n = 43). The final sample thus included 83 students (42 high-ability and 41 low-ability).

The selection of schools with similar contextual and infrastructural characteristics, similarity in student results coupled with the use of intact classes, preserved ecological validity by reflecting natural classroom dynamics while reducing the influence of school-level variables such as differences in teacher quality, resources and learning environment.

2.3 Instrumentation

Two instruments developed by the researchers were used for data collection: the Science Achievement Test (SAT) and the Basic Science Achievement Test (BSAT). Both were designed to evaluate students' understanding of relevant science concepts.

Science Achievement Test (SAT): The SAT consisted of 20 multiple-choice items drawn from JSS1 Basic Science topics. A table of specification guided item construction to ensure adequate coverage of content areas and cognitive domains (knowledge, comprehension, and application). Items were scored dichotomously (1 = correct, 0 = incorrect). For reliability testing, the SAT was pilot administered to 30 JSS1 students from another school who had already been taught the relevant content. Cronbach's alpha yielded 0.71, indicating acceptable reliability for a classroom-based achievement test.

Basic Science Achievement Test (BSAT): The BSAT, which assessed achievement on the topics taught during the intervention, was also structured with multiple-choice items and dichotomous scoring. It was pilot tested on 30 JSS3 students from another school who had previously covered the test content. The Cronbach's alpha coefficient was 0.68 marginally acceptable but usable for comparative research in exploratory contexts.

Validity and Item Analysis: Face and content validity were established through expert review by two science educators and one assessment specialist. The experts confirmed clarity, curriculum alignment, relevance, and cognitive appropriateness. Additionally, item analysis (difficulty index and discrimination index) was performed. Based on the results, one item was revised due to a low discrimination index, which improved the test's ability to differentiate between high- and low-achieving students.

2.4 Procedure

The intervention took place for a total of seven weeks. In Week 1, students completed the SAT and a BSAT pre-test. For six weeks, the experimental group received traditional lectures enhanced by animation videos played from the teacher's smartphones while the control group received only lecture-based instruction. All students completed a BSAT post-test in Week 7. Topics were aligned with the second-term Basic Science curriculum, and ethical approvals were obtained from school principals.

2.5 Data Analysis

Data was collected and analyzed using SPSS. Descriptive statistics (means) and inferential tests (independent samples t-test and ANCOVA) were used to determine significant differences in achievement across groups and ability levels.

3. Results

3.1 Research Question One

Does integrating animation videos into science instruction improve students' achievement on the Basic Science Achievement Test (BSAT) compared to lecture-only instruction?

Table 1. Pretest and Post-test Achievement Scores of Students on BSAT

Method	N	Post-Test Mean	SD	Pre-Test Mean	SD	Mean Gain (Post - Pre)
Animation video instruction	43	12.12	2.67	6.79	1.83	5.33
Lecture-only	40	10.68	2.60	6.10	1.75	4.58
Between-group Difference		1.44		0.69		0.75

The data in Table 1 shows that students in the animation video instruction group attained a higher post-test mean score (M = 12.12, SD = 2.67) than their lecture-only counterparts (M = 10.68, SD = 2.60). Similarly, the mean gain in achievement was greater for the animation video group (5.33) than the lecture group (4.58), resulting in a between-group gain difference of 0.75. These findings suggest that animation video integration may enhance students' science achievement more effectively than lecture-only instruction. Although the improvement is modest, it highlights the potential of multimedia-enhanced pedagogy to foster conceptual understanding, particularly in under-resourced rural contexts.

3.2 Research Question Two

How does the integration of animation videos into science instruction affect the science achievement of students with high and low ability levels in under-resourced rural schools?

Table 2. Interaction Effects of Instructional Method and Ability Level on Students' Achievement in BSAT

Method	Ability Level	N	Post-Test Mean	SD	Pre-Test Mean	SD	Mean Gain
Lecture-only	High ability	19	12.32	2.31	6.63	1.61	5.68
	Low ability	21	9.19	1.89	5.62	1.77	3.57
Total		40	10.68	2.61	6.10	1.75	4.58
Animation	High ability	23	12.43	2.56	7.52	1.73	4.91
	Low ability	20	11.75	2.83	5.95	1.61	5.80
Total		43	12.12	2.67	6.79	1.83	5.33
Overall Total	High ability	42	12.38	2.42	7.12	1.71	5.26
	Low ability	41	10.44	2.69	5.78	1.68	4.66
Grand Total		83	11.42	2.72	6.46	1.82	4.97

Table 2 presents the interaction between instructional method (lecture-only vs. animation videos) and student ability level (high vs. low).

Overall, students taught with animation videos achieved a higher mean gain (5.33) compared to those taught with lectures (4.58). High-ability students recorded greater post-test achievement (M = 12.38, SD = 2.42) than low-ability students (M = 10.44, SD = 2.69).

Notably, in the lecture-only group, high-ability students achieved the greatest improvement (mean gain = 5.68), outperforming even their high-ability peers in the animation group (mean gain = 4.91). Although this difference was not statistically significant, the trend is meaningful. It suggests that high-ability learners may already possess the cognitive strategies to benefit from traditional instruction, which in some cases may yield slightly greater gains than animation-based instruction.

By contrast, in the animation video group, low-ability students achieved the highest improvement (mean gain = 5.80), exceeding both their lecture-only peers (3.57) and even high-ability students in the same group (4.91). This suggests that animation videos may provide compensatory support for learners with lower initial ability, offering visual and contextual scaffolding that enhances understanding. Also, the high ability must have downplayed the effect of the vide instruction over their familiarity with the lecture method.

Ranking of mean gains across subgroups was as follows:

Low-ability students with animation videos (5.80)

High-ability students with lecture-only (5.68)

High-ability students with animation videos (4.91)

Low-ability students with lecture-only (3.57)

This pattern demonstrates the differentiated impact of instructional methods. While lecture methods may still serve high-ability learners effectively, animation videos level the playing field by significantly supporting low-ability learners, thereby narrowing achievement gaps in under-resourced contexts.

3.3 Hypothesis One

There is no significant difference in the Basic Science Achievement Test (BSAT) scores between students taught with integrated animation video into instruction and those taught using lecture-only instruction.

Table 3. T-test Results of Students Taught with Lecture and Animated Videos

Method		N	Mean	Std. Dev	Mean Diff	df	t	. Sig	Std. Error Diff	Effect size
post-test BSAT	Videos	43	12.11	2.6744	1.4413	81	2.484	.015	.58027	0.276
	Lecture	40	10.67	2.6055						
pre-test BSAT	Videos	43	6.79	1.8330	.69070	81	1.753	.083	.39411	
	lecture	40	6.10	1.7511						

The results of the pre-test conducted on both groups, as shown in Table 3, suggest that there was a difference of 0.6907 in the mean scores. However, the t-test (1.753), sig, 2-tailed (0.083) revealed no statistically significant difference between the two groups, indicating that their performance on the pre-test was comparable and suggests that before the teaching methods were applied, there was no difference in knowledge or ability between the groups. This result establishes baseline comparison after the intervention.

The results also show that there was a mean difference of 1.44128 between the post-test means of the students taught with animated videos and those taught with the lecture group. And the t-test analysis revealed a slight significant difference was found ($t=2.484$, $p<0.015$). The effect size of 0.276 indicates a small to medium range according to Cohen's (1988) translating to about 26.7% of the variance in means of students in the two groups and indicates that the use of animated videos have a noticeable but not a dramatic effect on the students post-test achievement than the use of lecture method. Based on these results, the hypothesis one is rejected.

3.4 Hypothesis Two

There is no significant difference in BSAT scores between high-ability and low-ability students taught using integrated animation video instruction and those taught using lecture-only instruction.

Table 4. T-test Summary of High and Low Ability Groups by Instructional Methods

Method	Ability Level	N	Mean	Std. Dev	df	t	Sig. (2-tailed)	Mean Diff	Std. Error Diff	Cohen's d	Effect Size Category
Lecture	High	19	12.32	2.31	38	4.70	0.000	3.13	0.6644	0.76	Large (A)
Lecture	Low	21	9.19	1.88							
animated video	High	23	12.43	2.56	41	0.83	0.409	0.68	0.820	0.13	Small (B)
animated video	Low	20	11.75	2.83							
Lecture	Low	21	9.19	1.88	39	-3.43	0.001	-2.56	0.7470	0.55	Medium-Large (C)
animated video	Low	20	11.75	2.83							
Lecture	High	19	12.32	2.31	40	0.157	0.876	-0.11	0.759	0.03	Negligible (D)
animated video	High	23	12.43	2.55							

Analysis following hypothesis two revealed the following:

Category A (Lecture: High vs. Low ability):

Significant difference ($t\ (38) = 4.70$, $p < .001$), with a large effect size ($d = 0.76$). High-ability students significantly outperformed low-ability peers under lecture instruction.

Category B (Animation: High vs. Low ability):

No significant difference (t (41) = 0.83, p = .409), with a small effect size (d = 0.13). This suggests that animation videos benefited both ability levels equally, producing a more equitable outcome.

Category C (Low ability: Lecture vs. Animation):

Significant difference (t (39) = -3.43, p = .001), favoring animation videos. The medium-large effect size (d = 0.55) indicates that animations were particularly beneficial for low-ability students.

Category D (High ability: Lecture vs. Animation):

No significant difference (t (40) = 0.157, p = .876), with negligible effect size (d = 0.03). High-ability students performed equally well under both instructional methods.

Based on the statistical outcomes: The null hypothesis is rejected for Categories A and C, where significant differences were found in favor of the lecture method for high-ability students (A) and the video method for low-ability students (C). The null hypothesis is retained for Categories B and D, indicating no significant difference between ability groups using animated videos (B) and between methods for high-ability students (D).

3.5 Hypothesis Three

There is no significant interaction effect between instructional method (animation video integration vs. lecture-only) and students' ability level (high vs. low) on their science achievement.

Table 5. Tests of Between-Subjects Effects

Dependent Variable: post-test PLAT					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	155.467a	4	38.867	6.696	.000
Intercept	515.231	1	515.231	88.760	.000
PREPLAT	9.971	1	9.971	1.718	.194
Method	29.248	1	29.248	5.039	.028
Ability	47.687	1	47.687	8.215	.005
Method * Ability	33.547	1	33.547	5.779	.019
Error	452.774	78	5.805		
Total	11436.000	83			
Corrected Total	608.241	82			

a. R Squared = .256 (Adjusted R Squared = .217) with pre-test as covariates

The results from the ANCOVA, controlling for pre-test BSAT scores, indicate that there is a statistically significant main effect of instructional method on students' post-test achievement (F(1, 78) = 5.039, p = .028), suggesting that the type of instruction—whether instruction plus animation videos or lecture alone has a meaningful impact on learning outcomes. A significant main effect of ability level was also observed (F (1, 78) = 8.215, p = .005), indicating that high-ability students, overall, performed better than their low-ability counterparts. Crucially, there is a statistically significant interaction effect between instructional method and students' ability level (F (1, 78) = 5.779, p = .019), this indicates that the effectiveness of instruction depends on ability level. While high-ability students performed well regardless of method, low-ability students benefited disproportionately from animation video instruction. Thus, Hypothesis Three is rejected.

4. Discussion

This study investigated the impact of integrating animated videos into science instruction on the achievement of junior secondary school students in rural Nigeria. The results confirm persistent concerns raised in the literature about the inadequacy of lecture-based approaches in fostering meaningful science learning, particularly in resource-constrained contexts (WAEC, 2020; NECO, 2019; Alsadoon, Alkhawajah, & Suhaim, 2022). Consistent with Hypothesis One, students taught with animation videos significantly outperformed their counterparts taught with lecture-only instruction, underscoring the pedagogical value of multimodal and visually enriched instruction.

The findings align with Dual Coding Theory (Paivio, 1991), which posits that information is better retained when presented through verbal and visual channels. In this study, animated videos paired visual representation with narration, offering students a dual processing experience that facilitated deeper comprehension and recall. This supports earlier evidence by Blasco et al. (2016) and Tani, Manuguerra, and Khan (2022), who found that video-enhanced instruction increases engagement and promotes conceptual learning.

However, closer analysis of Table 2 reveals a notable trend: among high-ability students, the lecture-only group recorded a slightly higher gain (5.68) than their counterparts in the animation group (4.91), though the difference was not statistically significant. One explanation may be that high-ability students are already equipped with strong abstract reasoning skills and are able to benefit from direct lecture delivery without requiring visual scaffolding (Chen & Wu, 2019; Zhang & Zhou, 2020). For these students, the additional cognitive load of processing animated visuals may have produced diminishing returns, a possibility echoed by Kim, Lee, and Kim (2019), who cautioned that video-based learning can sometimes distract or overwhelm advanced learners. This nuance highlights that while video-based methods are effective overall, their relative advantage may be more pronounced for lower-ability students who require additional visual supports.

Indeed, the study revealed a compensatory effect of animation videos for low-ability learners, whose achievement gains (5.80) surpassed all other subgroups, including high-ability students taught with either method. This reinforces findings by Hwang and Kim (2017) and Patel and Shah (2017), who observed that technology-enhanced instruction tends to narrow achievement gaps by providing struggling learners with alternative entry points into complex content. For rural Nigerian classrooms, where many students face barriers such as limited textbooks and inadequate teacher preparation, animation videos offer an accessible scaffold for learning. While the advantages are clear, it is equally important to acknowledge potential challenges and limitations in integrating technology into under-resourced environments. Studies such as Omini and Ofre (2021) and Kim et al. (2019) caution that technology adoption may fail if infrastructure, teacher training, and student motivation are inadequate. In contexts like rural Nigeria, barriers include unreliable electricity, limited device access, and lack of technical support. Wang and Hanna (2018) also note that high-ability students may disengage when technology does not sufficiently challenge them. Therefore, for sustained impact, technology integration should be complemented with professional development for teachers, curriculum adaptation, and infrastructural investment. Addressing these challenges makes the argument for video-enhanced pedagogy more comprehensive and realistic.

In sum, the findings demonstrate that animation video instruction fosters inclusivity by significantly supporting low-ability learners while still benefiting high-ability students. However, its effectiveness depends on thoughtful implementation that accounts for learner differences and contextual constraints.

5. Conclusion

Persistent underachievement in science subjects remains a critical challenge in rural and under-resourced Nigerian secondary schools, due to the continued reliance on traditional lecture-based instruction. This study addressed this issue by investigating the impact of integrating animation videos into Basic Science instruction, particularly among students of varying ability levels. Grounded in Dual Coding Theory, the study employed a quasi-experimental design to compare the academic achievement of students taught using animation video-supported instruction with those taught using lecture-only methods.

The results revealed that students exposed to animation video instruction performed significantly better than their counterparts in the control group. Notably, low-ability learners who typically lag in conventional instructional settings demonstrated marked improvement, while high-ability students also maintained strong achievement levels. These outcomes suggest that animation videos offer a multimodal learning experience that can bridge gaps in understanding, especially for learners with limited cognitive readiness for abstract scientific concepts.

The findings contribute to the ongoing discourse in curriculum and instructional design by emphasizing the practical and scalable value of using animation videos on affordable devices, such as smartphones, within low-resource settings. While both high- and low-ability learners benefited from the intervention, the results were particularly pronounced among low-ability students, who showed notably limited progress under traditional lecture-based instruction. This supports the argument for differentiated instruction that aligns with learners' cognitive needs and reinforces the theoretical propositions of Dual Coding Theory. In practice, it underscores the potential for context-sensitive educational technologies to promote equity in science education and foster more inclusive classroom environments.

However, the study was limited to a single subject area (Basic Science) and focused exclusively on junior secondary schools two students in rural Nigeria. It did not examine long-term retention, teacher capacity for sustained implementation, or other socio-emotional learning outcomes. Future research could explore the broader applicability of this instructional approach across subjects, age groups, and diverse geographical regions.

In conclusion, this study affirms that integrating animation videos into science instruction is not only effective but essential for transforming learning in disadvantaged contexts. It offers a pragmatic, theory-informed pathway toward achieving instructional equity and improving science outcomes for all learners, regardless of ability or setting.

6. Recommendations

Based on the findings, the following recommendations are proposed for educators, policymakers, and curriculum developers:

i. Educational authorities should equip rural schools with basic digital infrastructure, including devices and electricity supply, to facilitate animation video-instruction. Smartphones with pre-installed educational animations represent a cost-effective and accessible option for these contexts.

ii. Teachers should receive targeted training not only in the technical use of educational videos but also in pedagogical strategies for integrating them effectively into science instruction. Training programs should emphasize how to use videos to support students with varying ability levels.

iii. Policies should ensure that all students regardless of socioeconomic status or academic ability, have equal access to digital learning tools. Special attention should be paid to low-ability students who may require more structured and visual forms of learning support.

iv. Educators are encouraged to apply both lecture-based and animation video-based methods flexibly, depending on student needs. While high-ability students may thrive under either instructional format, low-ability students should be prioritized for video-supported instruction to help close achievement gaps.

v. Schools should implement continuous assessment systems to evaluate the effectiveness of instructional videos and adjust content or delivery approaches accordingly. Teachers and students should be involved in the feedback loop to ensure instructional materials remain relevant and effective.

6.1 Key Points

The study emphasizes the importance of adaptive video instructional strategies, especially in rural and resource-constrained educational settings. The followings are the key points from this study:

Animation video instruction increased student engagement and achievement, particularly for learners who struggle with abstract or text-heavy lectures.

A significant interaction effect was observed: high-ability students performed well under both methods, but low-ability students benefited more substantially from animation videos.

Animation videos displayed a compensatory effect, enabling low-ability students to surpass high-ability peers taught with lectures in terms of achievement gains.

Implementation challenges (e.g., infrastructure, teacher preparedness, resource limitations) must be addressed for sustainable integration.

The results advocate for investment in teacher training, educational technology, and context-sensitive curriculum design to promote inclusive science education.

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Authors contributions

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Data sharing statement

No additional data are available.